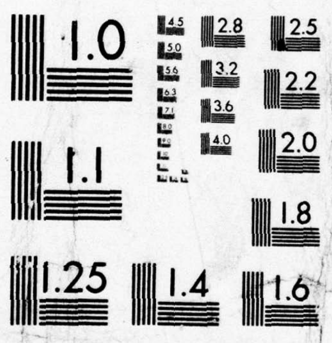
AD-A031 857 MARTIN MARIETTA LABS BALTIMORE MD F/G 13/9
ELECTROMECHANICAL MACHINING.(U)
JAN 76 R M LATANISION, K C NIELSEN DAAF03-73-C-0111
UNCLASSIFIED RIA-R-CR-76-015 NL

| OF |
AD
A031 857

END
DATE
FILMED
12-76



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

ADA031857

AD

R-CR-76-015

ELECTROMECHANICAL MACHINING

R. M. LATANISION

and

K. C. NIELSEN

JANUARY 1976

FINAL REPORT

U.S. ARMY ARMAMENT COMMAND

PREPARED BY Martin Marietta Corporation
Martin Marietta Laboratories
1450 South Rolling Road
Baltimore, Maryland 21227

Approved for public release; distribution unlimited.

PREPARED FOR

RESEARCH DIRECTORATE

GENERAL THOMAS J. RODMAN LABORATORY

ROCK ISLAND ARSENAL

ROCK ISLAND, ILLINOIS 61201

DISTRIBUTION INSTRUCTIONS:

Destroy this report when it is no longer needed. Do not return it to the originator.

DISCLAIMER:

The findings of this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

18 19

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. RE[redacted] NUMBER
RIA - R-CR-76-Ø15

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
6 ELECTROMECHANICAL MACHINING.

5. TYPE OF REPORT & PERIOD COVERED
9 Final Technical Rep[redacted]t,

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
10 R. M. Latanision
K. C. Nielsen

8. CONTRACT OR GRANT NUMBER(s)
15 DAAFØ3-73-C-Ø111 New

9. PERFORMING ORGANIZATION NAME AND ADDRESS
~~Martin Marietta Corporation~~
1 Martin Marietta Laboratories
1450 South Rolling Road
2 Baltimore, Maryland 21227

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
~~AMS CODE 3297.16.7035~~

11. CONTROLLING OFFICE NAME AND ADDRESS
CDR, Rock Island Arsenal
GEN Thomas J. Rodman Laboratory, SARRI-LR
Rock Island, Illinois 61201

12. REPORT DATE
11 Jan[redacted] [redacted]76

13. NUMBER OF PAGES
27 12 33p.

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

15. SECURITY CLASS. (of this report)
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

1. Machining
2. Electromechanical
3. Turning
4. Drilling
5. Electrolytic Controls
6. Thermoelectric Controls
7. 4140 Steel
8. CG 27 Alloy
9. Activation
10. Passivation

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The purpose of this work was to adapt the new process of electromechanical machining (EMM), in which metal is cut by direct contact of the tool with an electrochemically polarized workpiece, to turning and drilling. This investigation, which followed experiments in shaping, was focused on the turning and drilling of commercial alloys, particularly weapons materials such as 4140 steel and CG27 alloy, and the design and construction of a prototype EMM control console. over

(cont) over

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

407998

i

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. Abstract - continued

Electromechanical drilling of nickel-base alloys is most effective at potentials in the transpassive range of the polarization diagram for the workpiece in an aqueous Na_2SO_4 electrolyte. On the other hand, the penetration rate, tool life, cutting forces and hole surface finish experienced when drilling 4140 steel are far superior at active rather than passive, or neutral, potentials. These observations indicate the importance of proper selection of electrolytes and cutting potentials for each alloy of interest. Investigations showed that, at handbook recommendations for cutting speeds and feeds, electromechanical turning of 4140 steel was superior, in terms of cutting forces, to conventional turning. A portable, EMM control console, consisting of a 10-amp potentiostat, power supply, and related control for thermoelectric currents, was assembled. (R. Latanision and K. Nielsen)

FOREWORD

This report was prepared by R. M. Latanision,* Principal Investigator and K. C. Nielsen, Engineering Specialist, Martin Marietta Laboratories, in compliance with Contract DAAF03-73-C-0111 under the direction of the Research Directorate, General Thomas J. Rodman Laboratory, with R. A. Kirschbaum as Project Engineer.

This work was authorized as part of the Manufacturing Methods and Technology Program of the U.S. Army Materiel Development and Readiness Command, and was administered by the U.S. Army Industrial Base Engineering Activity.

* Dr. R. M. Latanision is currently with the Massachusetts Institute of Technology, Cambridge, Massachusetts.

CONTENTS

ILLUSTRATIONS

BACKGROUND

The basic objective of this program is to apply to metal cutting our fundamental understanding of the environment-sensitive mechanical behavior of metals -- understanding which has been developed at Martin Marietta Laboratories and Rock Island Arsenal's GEN Thomas J. Rodman Laboratory over several years. In particular, we expect to develop the new material-removal technique called "electromechanical machining (EMM)" to the stage where it can be used in manufacturing operations.

In the first year of this program, Phase I, the thrust of our effort was directed toward establishing the feasibility of EMM. This was demonstrated in the case of polycrystalline nickel workpieces cut on a shaper, nickel being chosen as an expedient, since the electrochemical and mechanical behavior of the Ni-1N H_2SO_4 system is well characterized. Nickel is, of course, the base for many commercially important superalloys, one of which -- Hastelloy X -- has been shown to be amenable to electromechanical assistance. During Phase I, we also examined the combination of EMM and thermoelectric compensation in order to achieve superior cutting performance. This work is documented in the final report for Phase I[1] and, in a condensed form, in a publication[2].

In its second year, Phase II, the program was directed toward applying EMM to the drilling and turning of commercial alloys, particularly weapons materials. It is clear the EMM must be taken beyond its use with a shaper (which presents a simple tool-workpiece system for evaluation, but is not of great practical significance), to more typical manufacturing machinery. In the following sections, we first describe electrolyte selection and then the extension of EMM concepts to Electromechanical Drilling (EMD) and Electromechanical Turning (EMT) of 4140 steel and CG27, a superalloy.

The final quarter of Phase II was devoted to the design and construction of a prototype EMM Control Console for delivery to Rock Island Arsenal. That effort also is described in this report.

APPROACH

In EMM, metal removal occurs by direct contact of a tool with an electrochemically polarized workpiece. Recognizing, firstly, that the removal of material in conventional metal cutting is governed by essentially two parameters -- namely, friction and the rate of work hardening of the workpiece -- and, secondly, that these parameters may be controlled electrochemically, it is not surprising to find [1,2] that the machining of metals should be significantly improved by making the workpiece an

---

[1] R. M. Latanision and K. C. Nielsen, Technical Report R-RR-T-6-35-73, to Research Directorate, General Thomas J. Rodman Laboratory, Rock Island Arsenal, May 1973.

[2] R. M. Latanision, K. C. Nielsen and R. Kirschbaum, "Electromechanical Machining", Modern Machine Shop, p. 69, vol 46, February 1974.

electrode*. At any rate, the point to note is that, in EMM, metal removal occurs by conventional means; and in principle, any conventional drill press, lathe, etc., is suitable provided the workpiece is exposed to an appropriate electrolyte. In this context, we have instrumented a drill press and lathe in order to examine the EMD and EMT behavior of alloys.

RESULTS AND DISCUSSION:

Electrolyte Selection

A considerable effort was concentrated on the selection of electrolytes to be used with specific alloys of interest in this machining investigation. It is important that the electrochemical action between the electrolyte selected and the material being machined provide the necessary characteristics for optimum results. In the case of Ni and Ni-base alloys, experience in Phase I showed that the polarization curves of the alloy-electrolyte combination should possess a reasonable passive region, a region during which the electrode is being slowly dissolved and a potential range over which hydrogen ions are being discharged at the electrode surface. Moreover, these conditions should exist at relatively low voltages.

Eighteen polarization curves were developed using carefully prepared specimens of CG27, 4140 and nickel in each of the following solutions:

H_2SO_4	Sulphuric Acid
Na_2SO_4	Sodium Sulfate
Na_2PO_4	Sodium Phosphate
$Na_2B_4O_7 : 10\ H_2O$	Sodium Borate
$Na_2MoO_4 \cdot 2\ H_2O$	Sodium Molybdate
$(NH_4)_6\ Mo_7O_{24} \cdot 4H_2O$	Ammonium Molybdate

The polarization curves of CG27 alloy, 4140 steel, and nickel in each of these electrolytes exhibit desired characteristics, i.e., an acceptable region of both passivation and of active dissolution. As will be seen later, it was discovered that passivating electrolytes are not the most effective for ferrous alloys.

Electromechanical Drilling

A Rockwell Delta precision drill press was instrumented for EMD evaluation in the form shown schematically in Fig. 1. In essence, the methodology is comparable to that used in earlier (Phase I) operations with a 7-in. shaper -- i.e., the workpiece is contained in a bath (1N aqueous Na_2SO_4), and the rate of penetration of carbide spade bits is

---

* The principles of EMM are discussed at length in References 1 and 2 and are not repeated here.

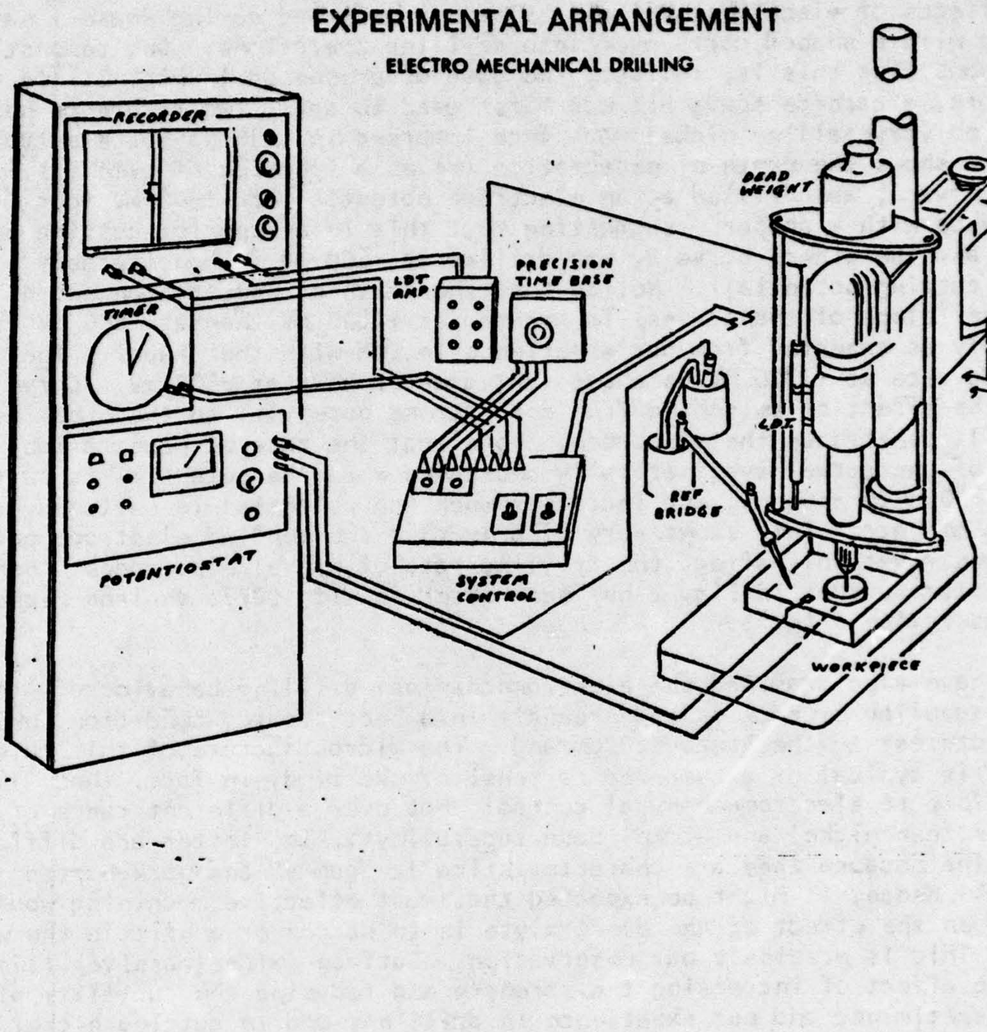


FIGURE 1 Schematic of the Electromechanical Drilling Apparatus.

monitored by means of a linear vertical displacement transducer as a function of the potential applied to the workpiece and controlled potentiostatically. The monitoring equipment -- X-Y recorder, ammeter, timer, etc. -- is housed in a portable control console with the power supply.

As previously noted, the alloys selected for use in the drilling operations are CG27 alloy and 4140 steel. However, the first tests were performed with nickel to establish the influence of applied potential on the drilling rate, and to verify during the drilling operation that the beneficial effects of electromechanical assistance (observed during Phase I machining with a shaper) carry over into drilling operations. One demonstration shows that this is, in fact, the case as presented in Fig. 2. In this work, a carbide spade bit was first used to drill two reference holes into a polycrystalline nickel workpiece immersed in a 1N Na_2SO_4 electrolyte. Figure 2 shows the depth of penetration (D) as a function of time (t). One hole, Curve 1, was drilled at an electrode potential of +1800 mV (our experience with a shaper suggesting that this is a superior cutting potential), and the other, Curve 2, was drilled at -600 mV (a considerably poorer cutting potential). Notice that the depth of penetration and drilling rate (slope of the curves) is greater at +1800 mV than at -600 mV -- precisely as expected from our experience in EMM with the shaper. The drilling rate at +1800 mV is about 100% greater than at -600 mV. Curve 3 shows the effect of switching from one extreme potential to the other as the drill penetrates the electrode. Note that the rate of penetration (slope of the curve) systematically decreases when the potential is switched from +1800 mV to -600 mV, and increases when the potential is switched back to +1800 mV, etc. This shows very clearly that the applied electrode potential does reversibly affect the drilling rate of nickel electrodes. Behavior similar to that in Fig. 2 has been observed with CG27, an iron-nickel-base superalloy, Fig. 3.

We have also examined the electromechanical drilling behavior of 4140 steel (supplied by Rock Island Arsenal) in a heat-treated condition, which is of interest to the Armament Command. The microstructure of this material, Fig. 4, is typical of a tempered martensite. We find, in fact, that 4140 is susceptible to electromechanical control, but over a different range of potentials than nickel and nickel-base superalloys. The latter are difficult to machine because they are characteristically "gummy" and work-harden rapidly. Hence, it might be expected that most effective machining would occur when the effect of the electrolyte is to harden or embrittle the workpiece. This is precisely our observation. Surface oxide (passive) films have the effect of increasing the strength and reducing the ductility of nickel specimens, and our experience in drilling, and in cutting nickel with a shaper, indicates that electrode potentials at which films are present on the surface (passive potentials) give best cutting performance. Conversely, one anticipates that the best cutting potential for a hardened 4140 steel would be one at which the influence of the electrolyte would be to soften the solid. This occurs not in the passive region for 4140 in a suitable electrolyte but in the active dissolution region -- i.e., in the range of potentials at which the surface is slowly being dissolved. As indicated below, this is consistent with our present findings, i.e., superior drilling performance of 4140 occurs at potentials in the region of active dissolution.

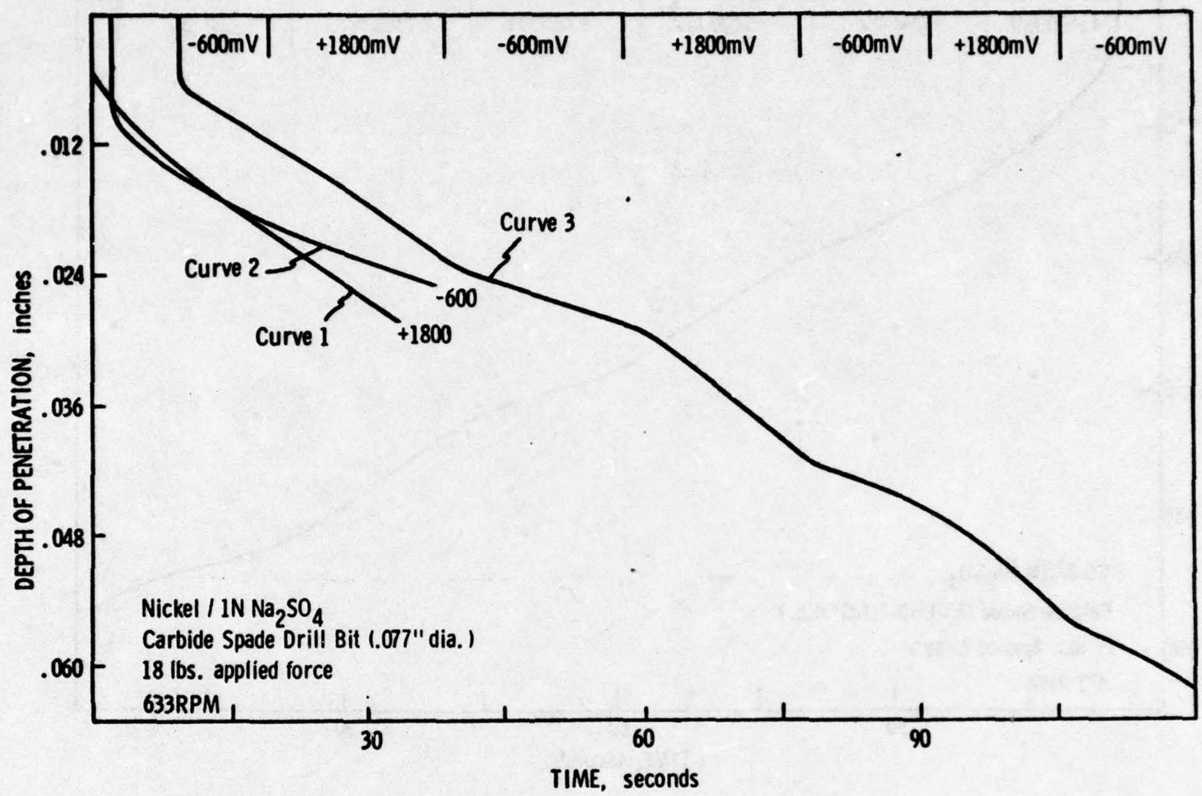


FIGURE 2 Electromechanical Drilling of Polycrystalline Nickel in 1N Na_2SO_4.

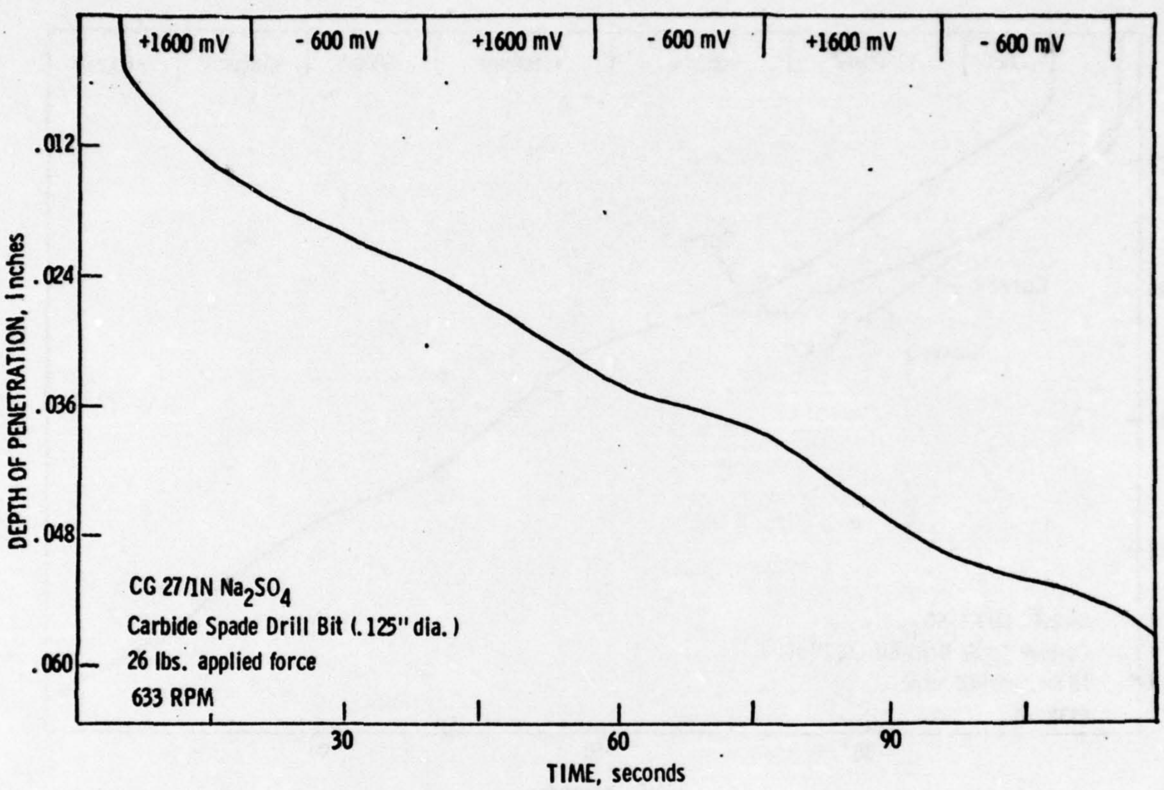


FIGURE 3 Electromechanical Drilling of CG27.

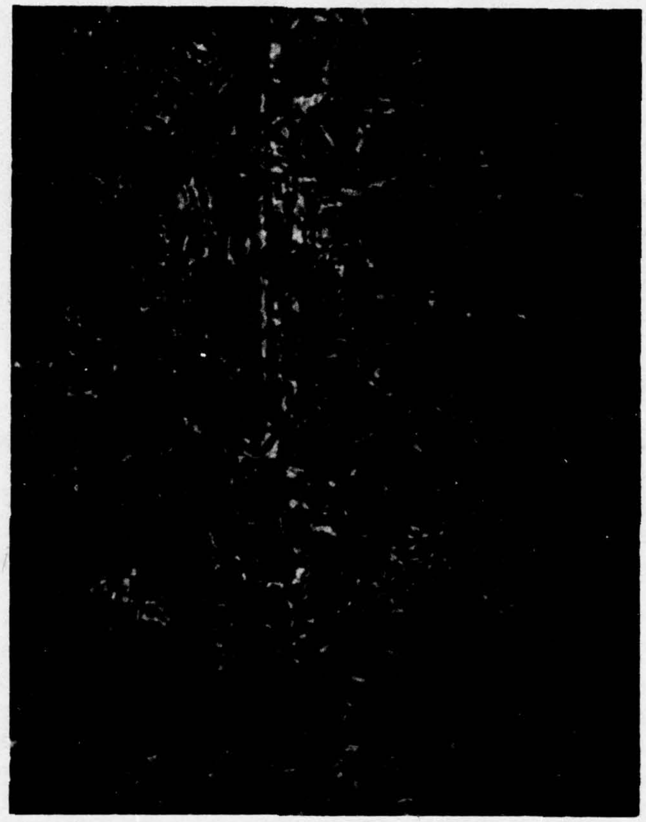


FIGURE 4 Microstructure of 4140 Steel as Received from the Rock Island Arsenal. (400X)

The polarization curve for 4140 in 1N Na_2SO_4 is shown in Fig. 5. The region of active dissolution ranges from the rest potential, ∿-700 to -100 mV.* At potentials more negative than the rest potential, hydrogen ions are discharged at the workpiece (cathode) surface. At potentials in the range from +300 to +1500 mV, the surface is passivated. Figure 6 shows the depth of penetration of a carbide drill bit as a function of time and workpiece potential. Notice first that potentials in both the hydrogen discharge range (-1100 mV) and passive range (+1800 mV) are extremely ineffective. On the other hand, the depth of penetration, penetration rate (slope of the curve) and tool life are far better at potentials in the active range (-600 to -400 mV). These data serve to illustrate the importance of proper selection of electrolytes and cutting potentials for each alloy of interest. Clearly, the cutting potentials which are effective for nickel and nickel-base alloys are not suitable for iron-base alloys.

We have also explored the benefit of thermoelectric compensation in drilling 4140 with carbide bits. Although this work was not emphasized or pursued to completion, it was clear that thermoelectric wear occurs in this system and may be controlled by the application of external currents. We have, therefore, applied external currents of up to 80 mA to the cutting tool via a brush; this brush is insulated from the machine, but it makes contact with a brass slip ring on the chuck of the drill press.

Electromechanical Turning of 4140 Steel

Specimens of 4140 round stock supplied by Rock Island Arsenal were cut into 12-inch lengths and fitted with a nylon insulating sleeve at the head stock end and a recessed nylon insulating plug at the tail stock end. The specimen center at the head stock end was fitted with a rotating probe in order to establish electrical contact. A photograph of the workpiece showing this insulation is provided in Fig. 7.

Instrumentation was the same as that used for the first tests (Phase I) with the shaper. Strain gages were affixed to the cutting tool holder, and their output signals were amplified and recorded as tool deflection (in microstrains) on a strip chart recorder. Inasmuch as turning operations do not lend themselves to submersion of the workpiece, a flood system was used to apply the electrolyte to the cutting tool and specimen (see Fig. 8). The cutting tools used were throw-away inserts -- V/R Wesson type Ramet 1 carbide. Tool geometry and cutting speed and feed were selected from the Machining Data and Engineering Guidelines (Revised)[3] as the starting point for turning 4140 steel under EMM conditions. The selected parameters were:

---

3 Machining Data and Engineering Guidelines (Revised), Technical Report SWERR-TR-72-60, Research Directorate, General Thomas J. Rodman Laboratory, Rock Island Arsenal, October 1972.

* Measurements were made relative to a standard calomel electrode (SCE) by means of a Luggin probe assembly.

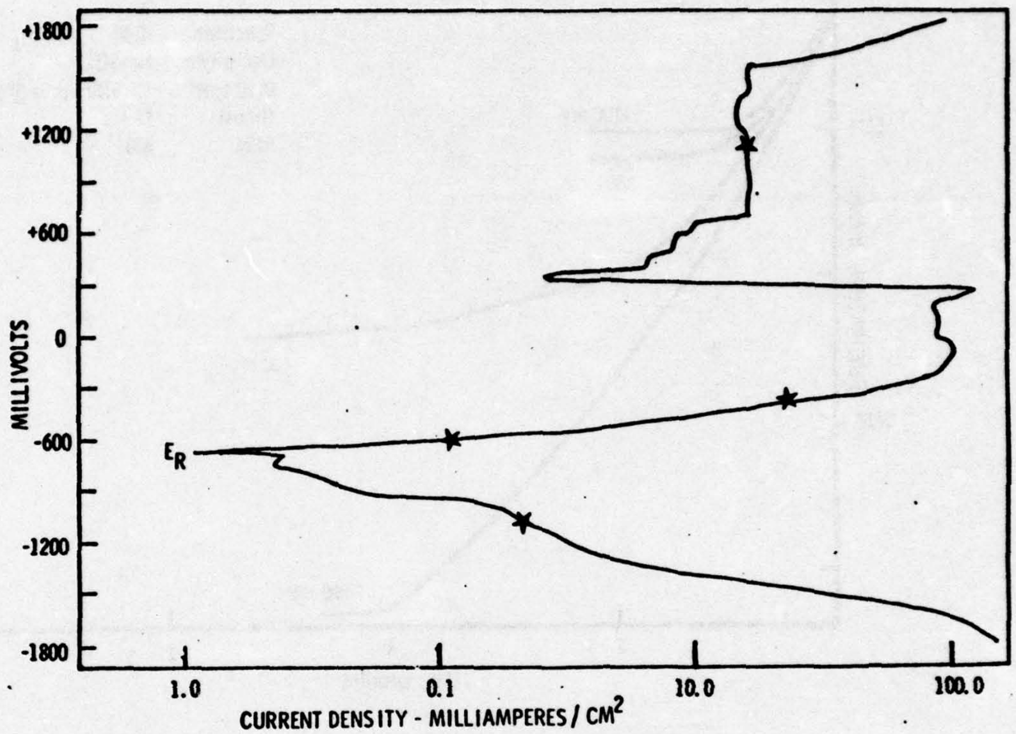


FIGURE 5 Polarization Curve for 4140 in 1N Na_2SO_4 at Room Temperature. Stars indicate applied potentials of interest to Figure 6.

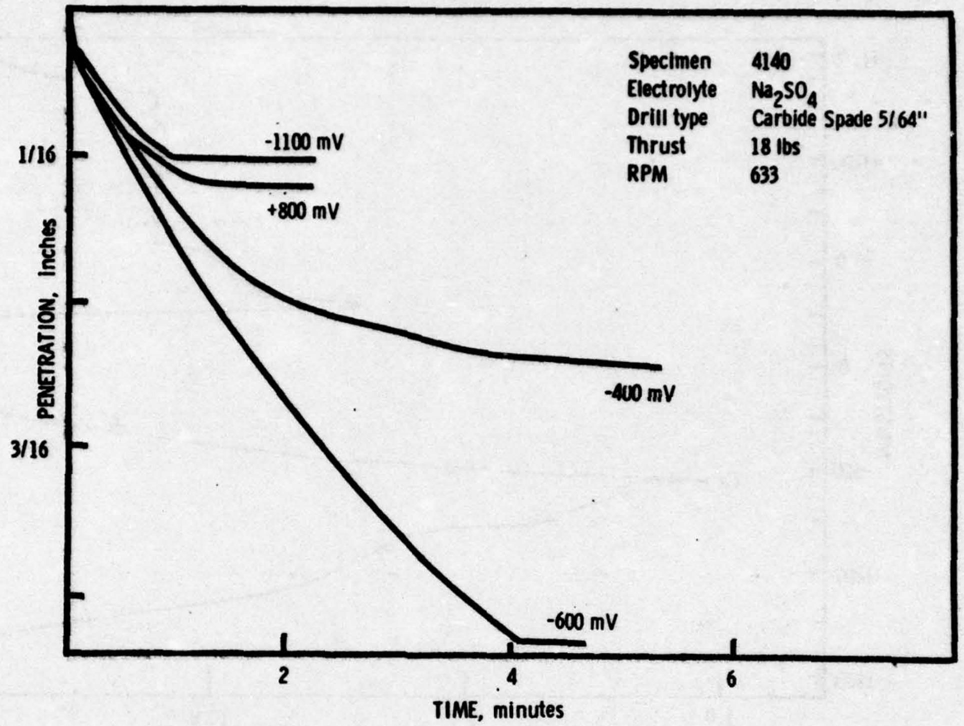


FIGURE 6 Depth of Penetration as a Function of Time and Workpiece Potential for Drilling 4140 Steel in 1N Na_2SO_4.

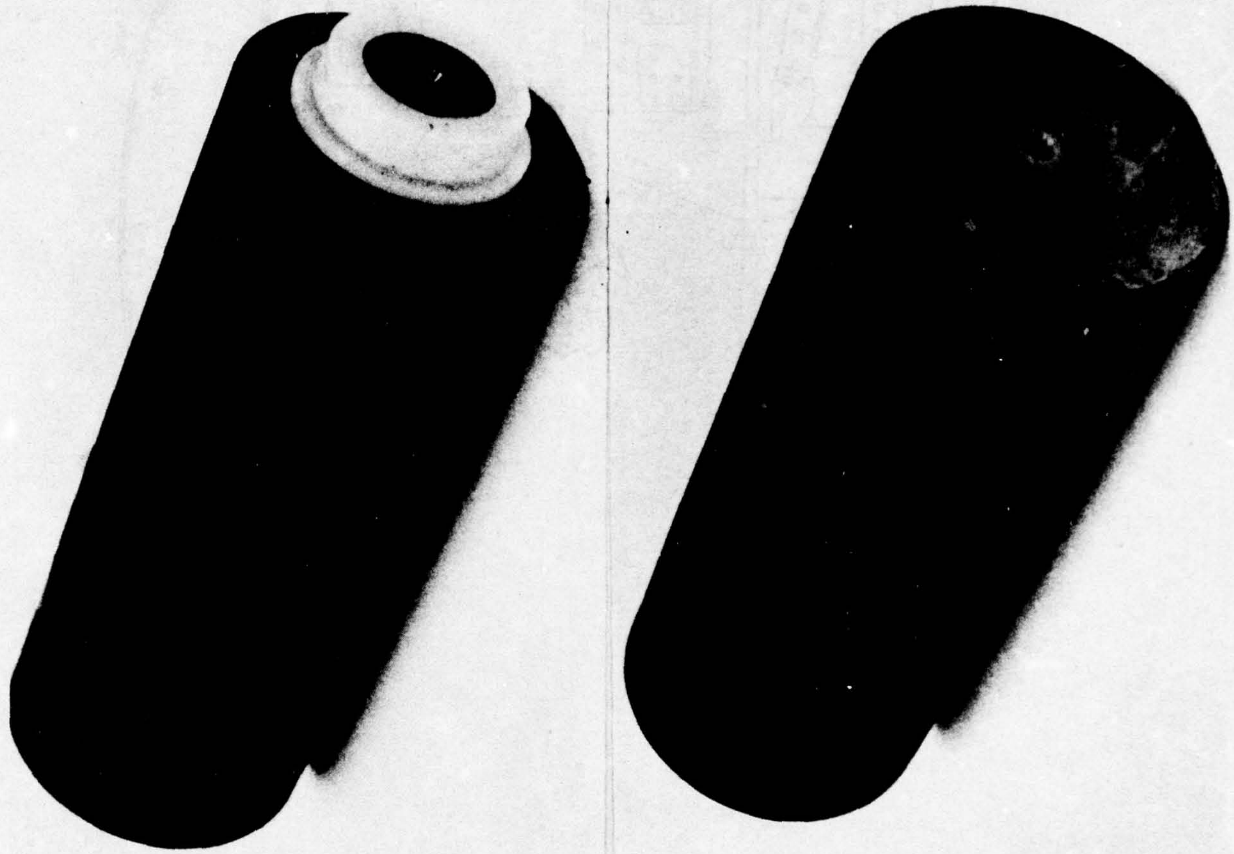


FIGURE 7 Photograph of 4140 Workpiece for Use in EMT Operations.

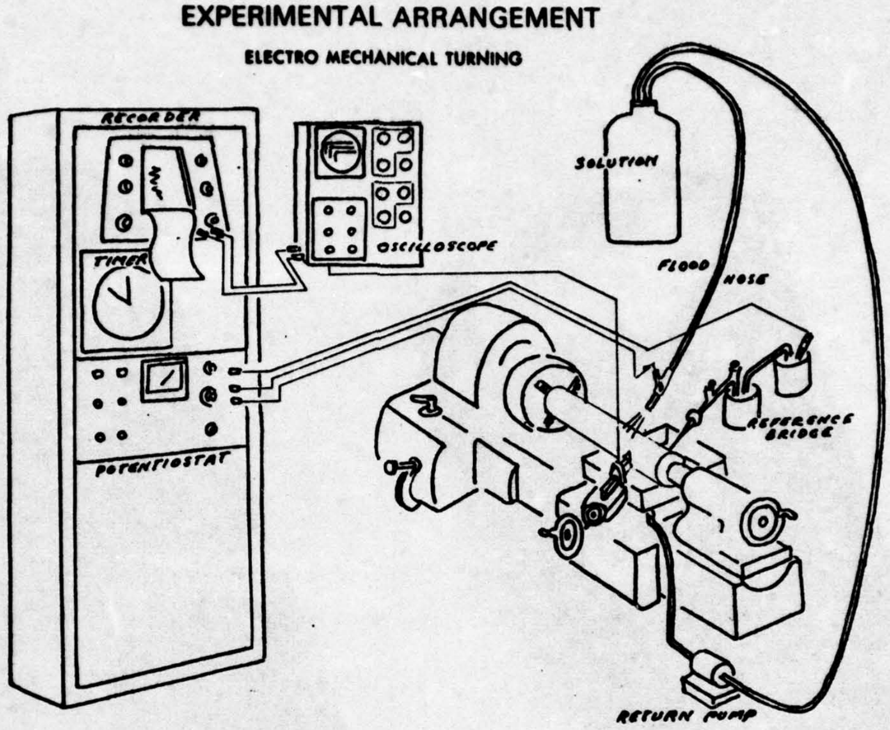


FIGURE 8 Schematic of EMT Apparatus.

Tool Geometry		Machining Data
Back rake angle	-5°	Speed: 500-535 fpm
Side rake angle	-5°	Feed: .007 ipr
End relief angle	5°	
Side relief angle	5°	
Side and end cutting edge angle	15°	
Nose radius	1/32"	

Because of the kinetics involved during turning, it was suspected that the polarization curve could possibly shift from the configuration found during a static determination of the curve. Therefore, a new polarization curve was plotted under dynamic conditions, i.e., with the workpiece turning but not being cut (Fig. 9). These curves were then used as a guide during EMT operations in a flood of sodium sulfate. The applied potentials utilized during this phase of testing were:

-300 mV	+1800 mV
-600 mV	+2000 mV
-1200 mV	Dry - no coolant
+600 mV	Oil - water soluble
+900 mV	

A total of 81 tests were made at these potentials, and the recordings were averaged for each potential. This series resulted in the graph shown in Fig. 10. It should be noted that the handbook recommends that with the use of carbide, generally no cutting fluid should be used. Relative to oil, Fig. 10 shows that as far as force is concerned, this recommendation is valid. That graph also shows a vivid picture of the effect of EMM compared to both dry and coolant methods of cutting. Although the +600 mV potential is indicated as the most advantageous point at which to operate EMM at this time, optimizing the system could shift this point to a lower potential.

A representative sample of recordings made at +600 mV, dry, and using water soluble oil, is shown in Fig. 11. Figures 10 and 11 indicate that the tool deflection at +600mV potential is 22% less than that at +900mV potential, 33% less than dry cutting and 38% less than cutting with water soluble oil. Therefore, it is clear in turning as in drilling and shaping operations that electromechanical assistance is beneficial.

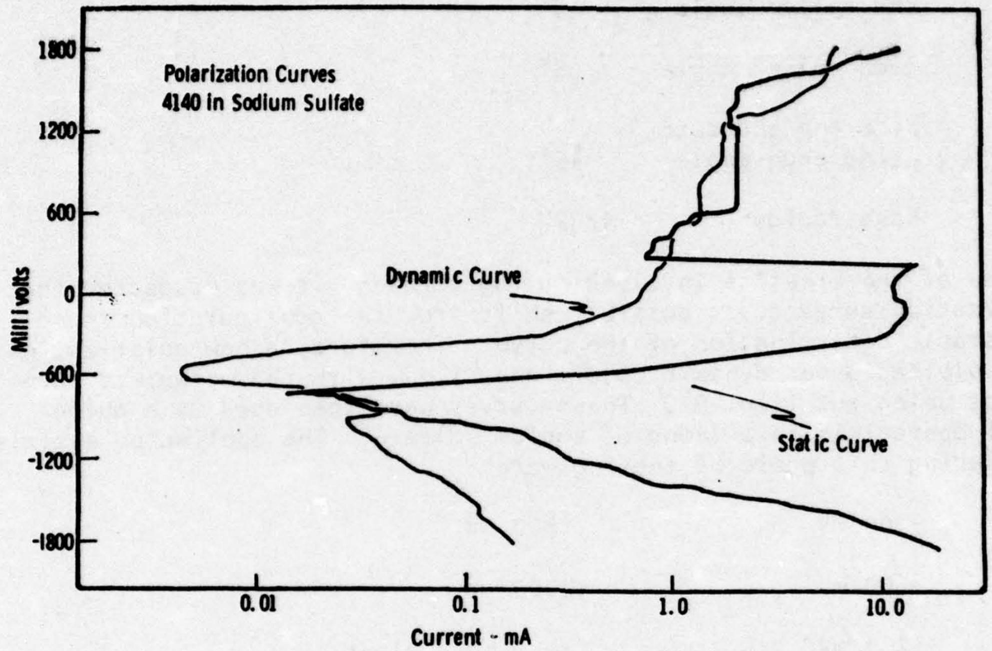


FIGURE 9 Polarization Curves for Static and Dynamic EMT Workpieces of 4140 in Na_2SO_4.

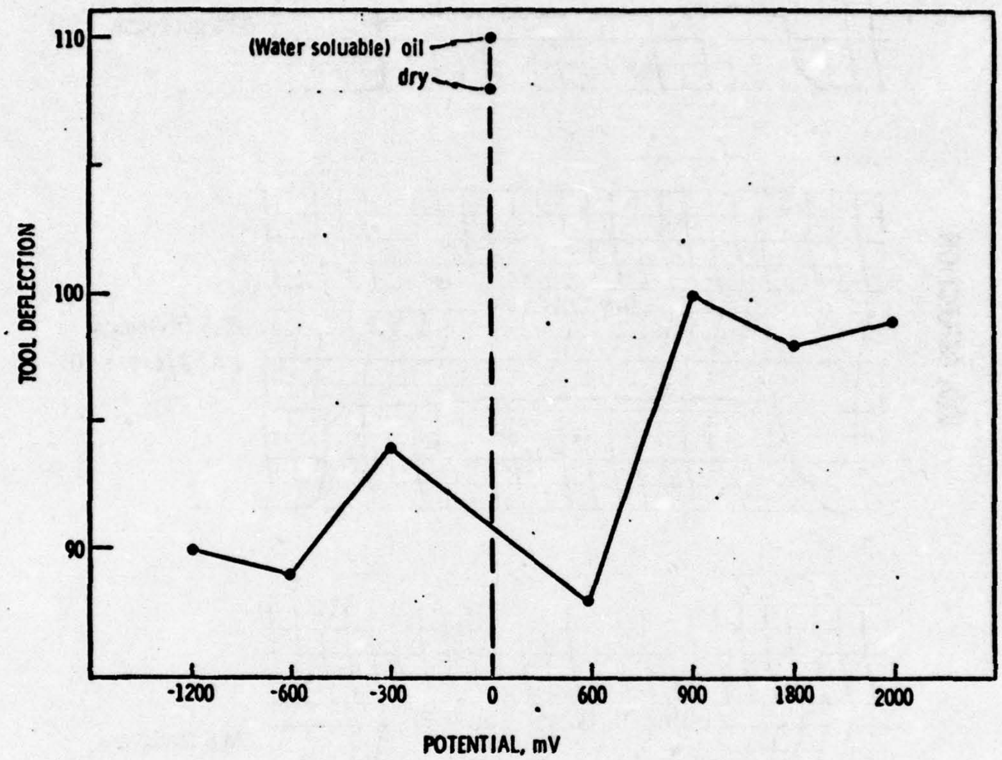


FIGURE 10 The Dependence of Tool Deflection on Applied Workpiece Potential During EMT of 4140 Steel in 1N Na_2SO_4.

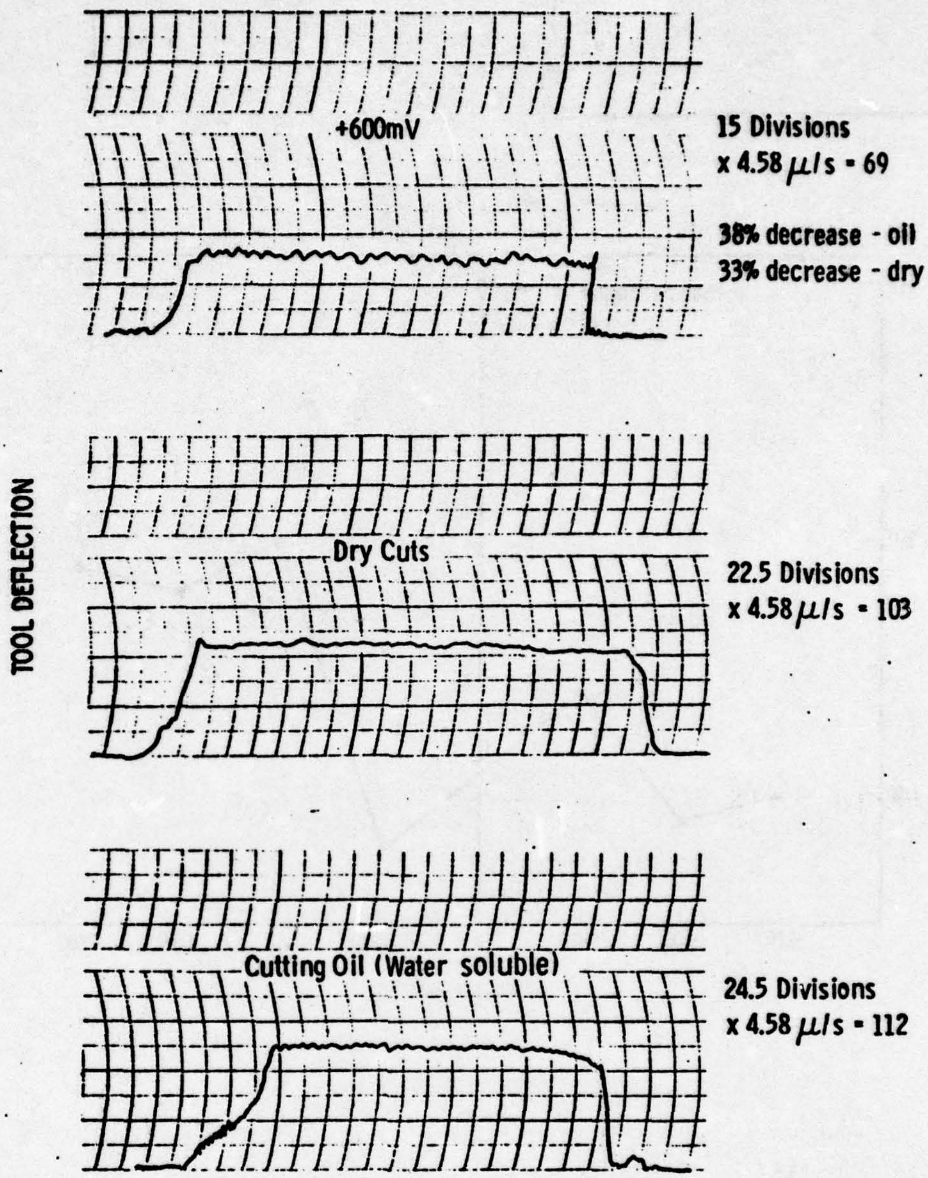


FIGURE 11 Recorder Traces Showing Tool Deflection Experienced in Turning 4140 Steel Under Various Conditions

Design and Construction of EMM Control Console for Delivery to Rock Island Arsenal

The EMM control console, Fig. 12, has been assembled. This console includes one 10-amp potentiostat, a power supply and a related panel for control of thermoelectric currents. The control console is undergoing final testing in actual use.

A preliminary set of operating instructions for turning and drilling has been written and has been supplied with the control console. This manual covers the set up and use of the console as applied to EMM and provides a set of operation and maintenance instructions on the potentiostate and power supply. A written description of the technique for drilling and turning has been completed along with the operating instructions of the equipment.

It should be recognized that the control console does not include monitoring equipment such as X-Y and strip chart recorders (which have been used in EMD and EMT operations, respectively). Such equipment may, however, be interfaced with the electronics included in the console. All other electrochemical gear (probes, reference electrode, etc.) has been delivered to the Arsenal with the console.

SUMMARY AND RECOMMENDATIONS

Extension of the electromechanical approach to metal cutting machinery and alloys more typical of manufacturing environment has been achieved. Electromechanical turning and drilling of polycrystalline nickel and CG27, an iron-nickel-base superalloy, have been successfully demonstrated. A prototype EMM console was designed, built and delivered to Rock Island Arsenal with an EMM operation and maintenance manual for turning and drilling. These achievements provide the background for broadening the EMM scope of activity in practical machining applications.

It is recommended that EMM be applied in the manufacture of a selected weapon component, such as a howitzer recoil piston rod, and that the cutting parameters (feed, speed, etc.) and electrolytic parameters (electrolyte, potential, etc.) be optimized to improve cutting time, tool life and surface integrity. Technically, in applying EMM, emphasis should be placed on taking advantage of the reduced cutting forces and improved surface finishes which the process provides. EMM should be applied to turning of long, cylindrical workpieces, such as recoil cylinder piston rods, which are not inherently stiff, and which presently require multiple-step, rough, semi-finish and finish turning.

Trends in the developments of work materials, cutting tools and coolants continue to indicate that wide spread adaptation and use of the EMM process is almost inevitable. Because of the low-energy process input, less than 2 amperes, or 2 volts, required to reduce cutting forces, up to 40%, and because of the resulting improved tool life, surface finishes or machining

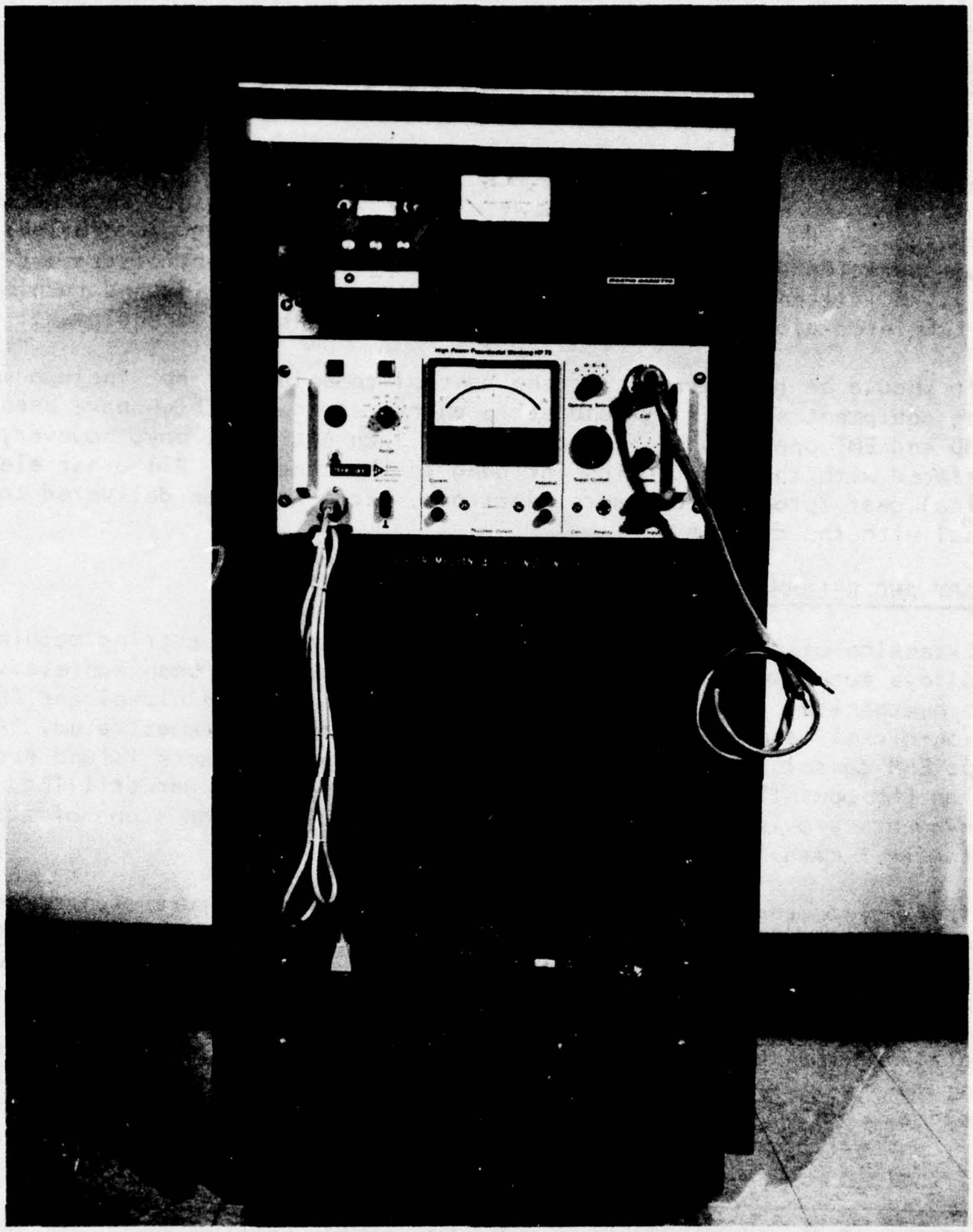


FIGURE 12 EMM Control Console

rates, obvious cost benefits cannot be ignored. However, continued development will be required to improve optimal use of EMM as related to different kinds of work materials.

LITERATURE CITED

1 R. M. Latanision and K. C. Nielsen, Technical Report R-RR-T-6-35-73, Research Directorate, General Thomas J. Rodman Laboratory, Rock Island Arsenal, May 1973.

2 R. M. Latanision, K. C. Nielsen and R. Kirschbaum, "Electromechanical Machining," Modern Machine Shop, p. 69, vol 46, February 1974.

3 Machining Data and Engineering Guidelines (Revised), Technical Report SWERR-TR-72-60, Research Directorate, General Thomas J. Rodman Laboratory, Rock Island Arsenal, October 1972.

DISTRIBUTION

	Copies
A. Department of Defense	
Defense Documentation Center ATTN: TIPDR Cameron Station Alexandria, VA 22314	12
B. Department of the Army	
Commander U. S. Army Materiel Development and Readiness Command	
ATTN: DRCRD-E	1
DRCRP-I	1
DRCQA-E	1
5001 Eisenhower Avenue Alexandria, VA 22333	
Commander U. S. Army Materiel Development and Readiness Command Scientific and Technical Information Team - Europe ATTN: DRXST-STL Dr. Richard B. Griffin APO New York 09710	1
Commander U. S. Army Armament Command	
ATTN: DRSAR-PPI-K	1
DRSAR-PPI-WW	1
DRSAR-RDP	1
DRSAR-SC	1
DRSAR-QAE	1
Rock Island, IL 61201	
Director U. S. Army Materials and Mechanics Research Center ATTN: DRXMR-M Watertown, MA 02172	1
Director U. S. Army Maintenance Management Center ATTN: DRXMD-A Lexington, KY 40507	1

DISTRIBUTION

	Copies
Commander U. S. Army Electronics Command ATTN: DRSEL-PP/I/IM Fort Monmouth, NJ 07703	1
Commander U. S. Army Missile Command ATTN: DRSMI-IIE DRSMI-PRT Redstone Arsenal, AL 35809	1 1
Commander U. S. Army Tank-Automotive Command ATTN: DRSTA-RK DRSTA-RCM.1 Warren, MI 48090	1 1
Commander U. S. Army Aviation Systems Command ATTN: DRSAV-ERE P. O. Box 209 St. Louis, MO 63166	1
Commander U. S. Army Troop Support Command ATTN: DRSTS-PLC 4300 Goodfellow Blvd. St. Louis, MO 63120	1
Commander Ballistic Missile Defense Systems ATTN: BNDSC-TS P. O. Box 1500 Huntsville, AL 35804	1
Project Manager Munition Production Base Mod Picatinny Arsenal Dover, NJ 07801	1
Commander Harry Diamond Laboratories ATTN: DRXDO-RCD 2800 Powder Mill Road Adelphi, MD 20783	1

DISTRIBUTION

	Copies
Commander U. S. Army Natick Research and Development Command ATTN: DRXNL-EQ Kansas Street Natick, MA 01762	1
Commander U. S. Army Air Mobility R&D Labs ATTN: SAVDL-ST Fort Eustis, VA 23604	1
Commander Rock Island Arsenal ATTN: SARRI-PE	1
SARRI-RS Mr. V. Long	1
Rock Island, IL 61201	
Commander Watervliet Arsenal ATTN: SARWV-PPP-WP	1
SARWV-PPI-LAJ	1
SARWV-QA	1
Watervliet, NY 12189	
Commander Picatinny Arsenal ATTN: SARPA-MT-C	1
SARPA-QA-T-T	1
SARPA-C-C	1
Dover, NJ 07801	
Commander Frankford Arsenal ATTN: SARFA-T1000	1
SARFA-QA	1
SARFA-N5400	2
Bridge & Tacony Streets Philadelphia, PA 19137	
Commander Edgewood Arsenal ATTN: SAREA-QA Aberdeen Proving Ground, MD 21010	1

DISTRIBUTION

	Copies
Director U. S. Army Industrial Base Engineering Activity ATTN: DRXIB-MT Rock Island Arsenal Rock Island, IL 61201	2
Director USDARCOM Intern Training Center ATTN: DRXMC-ITC-PPE Red River Army Depot Texarkana, TX 75501	1
Commander U. S. Army Tropic Test Center ATTN: STETC-MO-A (Technical Library) APO New York 09827	1
Commander Anniston Army Depot ATTN: DRXAN-DM Anniston, AL 36201	1
Commander Corpus Christi Army Depot ATTN: DRXAD-EFT Corpus Christi, TX 78419	1
Commander Fort Wingate Depot Activity ATTN: DRXFW-M Gallup, NM 87301	1
Commander Letterkenny Army Depot ATTN: DRXLE-M	1
DRXLE-MM Chambersburg, PA 17201	1
Commander Lexington-Blue Grass Army Depot ATTN: DRXLX-SE-1 Lexington, KY 40507	1

DISTRIBUTION

Copies

Commander
New Cumberland Army Depot
ATTN: DRSAR-ISS-A 1
New Cumberland, PA 17070

Commander
Pueblo Army Depot
ATTN: DRXPU-ME 1
DRXPU-SE 1
Pueblo, CO 81001

Commander
Red River Army Depot
ATTN: DRXRR-MM 1
Texarkana, TX 75501

Commander
Sacramento Army Depot
ATTN: DRXSA-MME-LB 1
Sacramento, CA 95813

Commander
Seneca Army Depot
ATTN: DRXSE-SE 1
Romulus, NY 14541

Commander
Sharpe Army Depot
ATTN: DRXSH-SO 1
DRXSH-M 1
Lathrop, CA 95330

Commander
Sierra Army Depot
ATTN: DRXSI-DQ 1
Herlong, CA 96113

Commander
Tobyhanna Army Depot
ATTN: DRXTO-ME-B 1
Tobyhanna, PA 18466

DISTRIBUTION

	Copies
Commander Tooele Army Depot ATTN: DRXTE-SEN DRXTE-EMD Tooele, UT 84074	 1 1
Commander Badger Army Ammunition Plant Baraboo, WI 53913	1
Commander Holston Army Ammunition Plant Kingsport, TN 37660	1
Commander Indiana Army Ammunition Plant Charleston, IN 47111	1
Commander Iowa Army Ammunition Plant Burlington, IA 52602	1
Commander Joliet Army Ammunition Plant Joliet, IL 60434	1
Commander Lone Star Army Ammunition Plant Texarkana, TX 75501	1
Commander Louisiana Army Ammunition Plant P. O. Box 30058 Shreveport, LA 71161	1
Commander Milan Army Ammunition Plant Milan, TN 38358	1
Commander Newport Army Ammunition Plant Newport, IN 47966	1

DISTRIBUTION

	Copies
Commander Radford Army Ammunition Plant Radford, VI 24141	1
Commander Ravenna Army Ammunition Plant Ravenna, OH 44266	1
Commander Riverbank Army Ammunition Plant Riverbank, CA 95367	1
Commander Scranton Army Ammunition Plant Scranton, PA 18501	1
Commander Sunflower Army Ammunition Plant Lawrence, KS 66044	1
Commander Twin Cities Army Ammunition Plant New Brighton, MN 55112	1
Commander Volunteer Army Ammunition Plant ATTN: SARVO-T P. O. Box 6008 Chattanooga, TN 37401	1

C. Department of the Navy

Officer in Charge U. S. Navy Materiel Industrial Resources Office ATTN: Code 227 Philadelphia, PA 19112	1

D. Department of the Air Force

Commander Air Force Materials Laboratory	
ATTN: LTE	1
LTM	1
LTN	1
Dayton, OH 45433	

DISTRIBUTION LIST UPDATE

- - - FOR YOUR CONVENIENCE - - -

Government regulations require the maintenance of up-to-date distribution lists for technical reports. This form is provided for your convenience to indicate necessary changes or corrections.

If a change in our mailing lists should be made, please check the appropriate boxes below. For changes or corrections, show old address *exactly* as it appeared on the mailing label. Fold on dotted lines, tape or staple the lower edge together, and mail.

☐ Remove Name From List

☐ Change or Correct Address

Old Address:

Corrected or New Address:

COMMENTS

Date: ____________________ Signature: ______________________________

Technical Report #

SARRI Form 900-643 (One-Time) (1 Feb 75)

AD ______ Accession No. ______

CDR, Rock Island Arsenal
GEN Thomas J. Rodman Lab
Rock Island, IL 61201

Martin Marietta Corp.
Martin Marietta Lab
1450 South Rolling Road
Baltimore, MD 21227

ELECTROMECHANICAL MACHINING, by R. M. Latanision and K. C. Nielsen - Martin Marietta Corporation

Report R-CR-76-015, Jan 76, 27 p. incl. illus and tables (Contract DAAF03-73-C-0111, AMS Code 3297.16.7035) Unclassified Report.

The purpose of this work was to adapt the new process of electromechanical machining (EMM), in which metal is cut by direct contact of the tool with an electrochemically polarized workpiece, to turning and drilling. This investigation, which followed experiments in shaping, was focused on the turning and drilling of commercial alloys, particularly weapons materials such as 4140 steel, and CG27 alloy, and the design and construction of a prototype EMM control console.

UNCLASSIFIED

1. Machining
2. Electromechanical
3. Turning
4. Drilling
5. Electrolytic Controls
6. Thermoelectric Controls
7. 4140 Steel
8. CG27 Alloy
9. Activation
10. Passivation

DISTRIBUTION
copies obtainable from DDC

AD ______ Accession No. ______

CDR, Rock Island Arsenal
GEN Thomas J. Rodman Lab
Rock Island, IL 61201

Martin Marietta Corp.
Martin Marietta Lab
1450 South Rolling Road
Baltimore, MD 21227

ELECTROMECHANICAL MACHINING, by R. M. Latanision and K. C. Nielsen - Martin Marietta Corporation

Report R-CR-76-015, Jan 76, 27 p. incl. illus and tables (Contract DAAF03-73-C-0111, AMS Code 3297.16.7035) Unclassified Report.

The purpose of this work was to adapt the new process of electromechanical machining (EMM), in which metal is cut by direct contact of the tool with an electrochemically polarized workpiece, to turning and drilling. This investigation, which followed experiments in shaping, was focused on the turning and drilling of commercial alloys, particularly weapons materials such as 4140 steel, and CG27 alloy, and the design and construction of a prototype EMM control console.

UNCLASSIFIED

1. Machining
2. Electromechanical
3. Turning
4. Drilling
5. Electrolytic Controls
6. Thermoelectric Controls
7. 4140 Steel
8. CG27 Alloy
9. Activation
10. Passivation

DISTRIBUTION
copies obtainable from DDC

AD ______ Accession No. ______

CDR, Rock Island Arsenal
GEN Thomas J. Rodman Lab
Rock Island, IL 61201

Martin Marietta Corp.
Martin Marietta Lab
1450 South Rolling Road
Baltimore, MD 21227

ELECTROMECHANICAL MACHINING, by R. M. Latanision and K. C. Nielsen - Martin Marietta Corporation

Report R-CR-76-015, Jan 76, 27 p. incl. illus and tables (Contract DAAF03-73-C-0111, AMS Code 3297.16.7035) Unclassified Report.

The purpose of this work was to adapt the new process of electromechanical machining (EMM), in which metal is cut by direct contact of the tool with an electrochemically polarized workpiece, to turning and drilling. This investigation, which followed experiments in shaping, was focused on the turning and drilling of commercial alloys, particularly weapons materials such as 4140 steel, and CG27 alloy, and the design and construction of a prototype EMM control console.

UNCLASSIFIED

1. Machining
2. Electromechanical
3. Turning
4. Drilling
5. Electrolytic Controls
6. Thermoelectric Controls
7. 4140 Steel
8. CG27 Alloy
9. Activation
10. Passivation

DISTRIBUTION
copies obtainable from DDC

AD ______ Accession No. ______

CDR, Rock Island Arsenal
GEN Thomas J. Rodman Lab
Rock Island, IL 61201

Martin Marietta Corp.
Martin Marietta Lab
1450 South Rolling Road
Baltimore, MD 21227

ELECTROMECHANICAL MACHINING, by R. M. Latanision and K. C. Nielsen - Martin Marietta Corporation

Report R-CR-76-015, Jan 76, 27 p. incl. illus and tables (Contract DAAF03-73-C-0111, AMS Code 3297.16.7035) Unclassified Report.

The purpose of this work was to adapt the new process of electromechanical machining (EMM), in which metal is cut by direct contact of the tool with an electrochemically polarized workpiece, to turning and drilling. This investigation, which followed experiments in shaping, was focused on the turning and drilling of commercial alloys, particularly weapons materials such as 4140 steel, and CG27 alloy, and the design and construction of a prototype EMM control console.

UNCLASSIFIED

1. Machining
2. Electromechanical
3. Turning
4. Drilling
5. Electrolytic Controls
6. Thermoelectric Controls
7. 4140 Steel
8. CG27 Alloy
9. Activation
10. Passivation

DISTRIBUTION
copies obtainable from DDC

Electromechanical drilling of nickel-base alloys is most effective at potentials in the transpassive range of the polarization diagram for the workpiece in an aqueous Na_2SO_4 electrolyte. On the other hand, the penetration rate, tool life, cutting forces and hole surface finish experienced when drilling 4140 steel are far superior at active rather than passive, or neutral, potentials. These observations indicate the importance of proper selection of electrolytes and cutting potentials for each alloy of interest. Investigations showed that, at handbook recommendations for cutting speeds and feeds, electromechanical turning of 4140 steel was superior, in terms of cutting forces, to conventional turning. A portable, EMM control console, consisting of a 10-amp potentiostat, power supply, and related control for thermoelectric currents, was assembled.

Electromechanical drilling of nickel-base alloys is most effective at potentials in the transpassive range of the polarization diagram for the workpiece in an aqueous Na_2SO_4 electrolyte. On the other hand, the penetration rate, tool life, cutting forces and hole surface finish experienced when drilling 4140 steel are far superior at active rather than passive, or neutral, potentials. These observations indicate the importance of proper selection of electrolytes and cutting potentials for each alloy of interest. Investigations showed that, at handbook recommendations for cutting speeds and feeds, electromechanical turning of 4140 steel was superior, in terms of cutting forces, to conventional turning. A portable, EMM control console, consisting of a 10-amp potentiostat, power supply, and related control for thermoelectric currents, was assembled.

Electromechanical drilling of nickel-base alloys is most effective at potentials in the transpassive range of the polarization diagram for the workpiece in an aqueous Na_2SO_4 electrolyte. On the other hand, the penetration rate, tool life, cutting forces and hole surface finish experienced when drilling 4140 steel are far superior at active rather than passive, or neutral, potentials. These observations indicate the importance of proper selection of electrolytes and cutting potentials for each alloy of interest. Investigations showed that, at handbook recommendations for cutting speeds and feeds, electromechanical turning of 4140 steel was superior, in terms of cutting forces, to conventional turning. A portable, EMM control console, consisting of a 10-amp potentiostat, power supply, and related control for thermoelectric currents, was assembled.

Electromechanical drilling of nickel-base alloys is most effective at potentials in the transpassive range of the polarization diagram for the workpiece in an aqueous Na_2SO_4 electrolyte. On the other hand, the penetration rate, tool life, cutting forces and hole surface finish experienced when drilling 4140 steel are far superior at active rather than passive, or neutral, potentials. These observations indicate the importance of proper selection of electrolytes and cutting potentials for each alloy of interest. Investigations showed that, at handbook recommendations for cutting speeds and feeds, electromechanical turning of 4140 steel was superior, in terms of cutting forces, to conventional turning. A portable, EMM control console, consisting of a 10-amp potentiostat, power supply, and related control for thermoelectric currents, was assembled.